

APPENDIX 2. AUTHOR RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 1: TRAINING IN CLINICAL CARDIOLOGY

Name	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
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This table represents the relationships of committee members with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication.

APPENDIX 3. PEER REVIEWER RELATIONSHIPS WITH INDUSTRY—ACCF 2008 RECOMMENDATIONS FOR TRAINING IN ADULT CARDIOVASCULAR MEDICINE CORE CARDIOLOGY TRAINING (COCATS 3)—TASK FORCE 1: TRAINING IN CLINICAL CARDIOLOGY

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Dr. Chittur A. Sivaram	• Official—Board of Governors	• 3F Therapeutics	None	None	None	None	None	None
Dr. Laura F. Wexler	• Content—American Board of Internal Medicine	None	None	None	None	None	None	None

This table represents the relationships of peer reviewers with industry that were reported by the authors as relevant to this topic. It does not necessarily reflect relationships with industry at the time of publication.*Names are listed in alphabetical order with each category of review.

Task Force 2: Training in Electrocardiography, Ambulatory Electrocardiography, and Exercise Testing

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Electrocardiography

Importance

Electrocardiography is the most commonly used diagnostic test in cardiology. Properly interpreted, it contributes significantly to the diagnosis and management of patients with cardiac disorders. Importantly, it is essential to the diagnosis

of cardiac arrhythmias and the acute myocardial ischemic syndromes. These 2 conditions account for the majority of cardiac catastrophes. It is appropriately used as a screening test in many circumstances.

Goal of Training

Although every physician should have a basic knowledge of electrocardiography, and the general internist should have

more advanced knowledge than most others, the subspecialist in cardiology should be familiar with nearly all clinically encountered patterns of depolarization and repolarization and of arrhythmias. The trainee should understand clinical implications, sensitivity, and specificity of the test, and should be able to identify normal variants. The trainee should have sufficient basic knowledge to understand the physiologic mechanisms for arrhythmias and electrocardiographic waveforms rather than to simply recognize patterns. The recognition and understanding of the basis for the items included in Appendix 1 of this task force report are minimum requirements for each trainee.

The trainee should also be familiar with the instrumentation necessary to acquire, process, and store electrocardiograms (ECGs), in both analog and digital format. The trainee should understand the effect of acquisition rates and filter settings, as well as recognize electronic artifacts. The trainee should be able to accurately measure basic ECG intervals in both analog and digital systems.

Training

An essential feature of training is to interpret a large number of ECGs and to review all interpretations with experienced faculty. The committee recommends that all trainees achieve Level 2 training in ECG interpretation. This necessitates interpreting 3500 ECGs over 24 to 36 months (Table 1). These should be documented individually. This may be accomplished by 1 or more training periods assigned specifically for interpretation of ECGs, or it may be an experience provided in a continuing manner. The experience should include clinical correlation in patients in intensive care units, emergency rooms, and pacemaker/defibrillation clinics. The ECG should be integrated with the clinical problem. Formal courses and correlative conferences in electrocardiography are strongly recommended. In addition, guidelines for the role of electrocardiography in clinical practice should be thoroughly understood, reviewed, and followed (1).

In-Training Evaluation

The trainee must become familiar with the indications for electrocardiography and electrophysiologic studies. Similarly, the trainee should be familiar with the principles of intracardiac electrophysiologic studies, their indications, contraindications, sensitivity, and specificity (see the Task Force 6 report). The trainee should be evaluated on an ongoing basis by responsible faculty to determine that the trainee has integrated these knowledge bases. Because of variability in training in electrocardiography and to document the trainee’s proficiency, an in-training examination in electrocardiography should be used and implemented by each training program. The Adult Clinical Cardiology Self-Assessment Program (ACCSAP) contains a self-assessment examination in electrocardiography, which is available on a national basis and is useful for identifying knowledge areas of specific weakness and levels of proficiency.

Ambulatory ECG Monitoring

Importance

Observation and documentation of cardiac rhythm during daily activities, as well as the relation of the rhythm disturbances to patient symptoms, are important factors for clinical decision making. Major indications for ambulatory ECG monitoring include the following: detection of or ruling out of rhythm disturbances as a cause of symptoms; detection and assessment of arrhythmias believed to be associated with an increased risk for cardiovascular events; the identification and accurate interpretation of ambulatory ST-T wave changes occurring throughout a diurnal time period; assessment of efficacy of antiarrhythmic and anti-ischemic therapy; and investigation of the effects of therapeutic devices (e.g., pacemakers and implantable cardioverter-defibrillator).

Table 1 Summary of Training Requirements in Electrocardiography, Ambulatory Electrocardiography, and Exercise Testing						
Task Force	Area	Level	Minimal Number of Procedures	Cumulative Duration of Training (Months)	Minimal Cumulative Number of Cases	Comments
2	Electrocardiography	1	3500*†	36	3500	*Can be taken throughout the training program. †The committee strongly recommends that cardiologists achieve Level 2 training in ECG interpretation.
		2	3500			
	Ambulatory monitoring	1	150*		150	*Can be taken throughout the training program.
		2	75		225	
	Exercise testing	1	200*		200	*Can be taken throughout the training program.
		2	100		300	

ECG = electrocardiogram.

Goal of Training

The technology is not perfect, and multiple methods of recording and analysis are currently in use. The trainee should understand the differences between continuous and intermittent recordings and the advantages and disadvantages of each and should have a basic knowledge of the various methods used for arrhythmia and ST-segment detection, classification, and analysis. The trainee should understand the potential pitfalls inherent in each method. In addition, the trainee should have current knowledge about what may represent a “normal” finding for various age groups during sleeping and waking hours and what should be considered “abnormal,” realizing that the clinical significance of some findings on ambulatory monitoring is still unresolved.

Structure of Training

The trainee should participate in interpretation sessions with a staff cardiologist knowledgeable in the indications for the test, the techniques of recording, and the clinical significance and correlations of findings. It is recommended that the trainee interpret a minimum of 150 ambulatory ECG recordings over 24 to 36 months. Ideally, the trainee should be exposed to both full-disclosure (complete print-out) and computer-assisted systems so that the advantages, disadvantages, and cost of each may be understood. In addition, transtelephonic and event-recorder devices are increasingly used on an adjunct basis for prolonged ambulatory electrocardiography. Knowledge of their indications and limitations must also be gained, preferably from structured training in ambulatory electrocardiography that permits interaction of the trainee with an experienced cardiovascular technician and ambulatory ECG instrumentation and review of interpreted records with the attending cardiologist with specific expertise in ambulatory electrocardiography. Such training will provide knowledge to satisfy clinical competence in ambulatory electrocardiography as indicated by the American College of Cardiology (ACC)/American Heart Association (AHA)/American College of Physicians–American Society of Internal Medicine (ACP–ASIN) Task Force on Clinical Competence (1).

Level 2 trainees will interpret a minimum of 75 additional recordings over 12 months (a total of 225 recordings over 36 months). Such recordings or other provided material should include all forms of artifact, pacemaker, and implantable cardioverter-defibrillator patterns, heart rate variability studies, repolarization abnormalities (e.g., QT or T wave alternans), and applications of the signal-averaged ECG. Such trainees will demonstrate knowledge of the operation and limitations of a variety of types of ambulatory ECG instrumentation. Additional ECG interpretation of in-hospital telemetry ECGs is required. This may range from 6 to 8 s of real-time printout strips to 72 h of full-disclosure data. Such ECG data often augment standard and ambulatory electrocardiography. Trainees will be experienced in

the interpretation and limitations, since knowledge at this level also supports the objectives of Level 2 training in electrophysiology, pacing, and arrhythmia management (see the Task Force 6 report).

In-Training Evaluation

Because of the large number of different rhythm patterns seen during routine clinical ambulatory ECG recordings and the many technologic approaches, it may not be possible to assess adequately a trainee's expertise in ambulatory electrocardiography by a uniform, written examination. Thus, the trainee must be given the responsibility for initial interpretation of all phases of the ambulatory ECG study. The trainee should provide a detailed interpretation and review it with the attending cardiologist responsible and experienced in ambulatory electrocardiography. This attending cardiologist is responsible for the evaluation and documentation of a trainee's progress and skills.

Evolving New Applications

Long-term ambulatory electrocardiography continues to evolve with regard to QT measurements and heart rate variability studies. These measurements provide insight into ventricular repolarization changes and the autonomic nervous system (sympathetic and parasympathetic) over extended periods of ambulatory electrocardiography. Trainees should be cognizant of these developments and follow their evolution and clinical application.

Exercise Testing

Importance

Exercise testing is an important physiologic procedure used to elicit cardiovascular abnormalities not present at rest and to determine adequacy of cardiac function. These tests are valuable clinical procedures used to assess patients with suspected or proven cardiovascular disease. Exercise testing is used primarily to estimate prognosis, determine functional capacity, provide a diagnostic estimate of the likelihood and extent of coronary disease, and determine the effects of therapy. Exercise electrocardiography is also combined with ancillary techniques such as radionuclide imaging, echocardiography, or metabolic gas analysis to enhance the information content of the test in selected patients.

Goal of Training

The trainee should become proficient at performing both heart rate-limited and maximal or near-maximal treadmill exercise tests and should have the opportunity to learn alternative exercise testing techniques. The training program should provide the opportunity for the trainee to become knowledgeable in exercise physiology and pathophysiology. The trainee should also be taught the essentials of exercise testing, such as skin preparation, electrode selection and application, choice of exercise testing proto-

cols, blood pressure monitoring during exercise, and monitoring of the patient for adverse signs or symptoms. The trainee should be thoroughly familiar with evidence-based indications and contraindications to exercise testing. The trainee must become proficient in the interpretation of commonly used measurements available from the exercise test. These include the onset and offset of ischemic ST-segment depression and the distinction between normal variants and abnormal patterns, exercise-induced cardiac arrhythmias, magnitude and slope of ST-segment depression or elevation, ST/heart rate indexes, exertional hypotension, chronotropic incompetence, heart rate recovery, and hemodynamic measurements such as maximum exercise heart rate, systolic blood pressure, and double product. The trainee should become proficient in integrating the data, understanding the reasons for stopping exercise, and establishing diagnostic accuracy (sensitivity and specificity) and prognostic importance of the procedure in different clinical settings as described in the ACC/AHA guidelines for exercise testing (2). This training will provide knowledge to satisfy clinical competence in exercise testing, as indicated by the ACC/AHA/ACP-ASIN Task Force on Clinical Competence.

Structure of Training and In-Training Evaluation

The training of a fellow in cardiology should include at least 2 months, or the equivalent, of active participation in a fully equipped exercise testing laboratory, during which time the fellow should perform a minimum of 200 exercise tests reviewed by faculty. This experience can be obtained concurrently with training in an exercise imaging laboratory as part of the training requirements in nuclear cardiology or echocardiography. Level 1 trainees will gain proficiency in the standard exercise test and its interpretation (minimum experience 200 tests), to include pharmacologic testing (dipyridamole, adenosine, and dobutamine), whereas Level 2 trainees (additional 100 tests) will become experienced in advanced forms of exercise testing, which include arrhythmia evaluation, ventilatory gas studies, pulmonary function testing as part of cardiopulmonary stress testing, stress echocardiographic techniques, and nuclear cardiology (see the Task Force 4 and 5 reports).

The laboratory should be engaged in the performance of exercise tests on a regular basis that involve a broad spectrum of both inpatients and outpatients with a variety of known and suspected cardiac disorders. The training program should be structured so that the trainee is guided in the laboratory by a specially trained exercise professional until the trainee has become proficient at conducting and monitoring exercise tests under a variety of clinical circumstances. The trainee must be given the responsibility for initial interpretation of all phases of the exercise study, providing a detailed interpretation, and reviewing it with the attending cardiologist responsible and experienced in exercise testing. The faculty physician should assess and

document the trainee's progress on a regular basis, including technical performance and ability to interpret results.

This is a revision of the 2002 document that was written by Robert J. Myerburg, MD, FACC—Chair; Bernard R. Chaitman, MD, FACC; Gordon A. Ewy, MD, FACC; and Melvin M. Scheinman, MD, FACC.

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TASK FORCE 2 REFERENCES

1. Kadish AH, Buxton AE, Kennedy HL, et al. ACC/AHA clinical competence statement on electrocardiography and ambulatory electrocardiography: a report of the ACC/AHA/ACP-ASIM Task Force on Clinical Competence (ACC/AHA Committee to Develop a Clinical Competence Statement on Electrocardiography and Ambulatory Electrocardiography). *J Am Coll Cardiol* 2001;38:2091–100.
2. Rodgers GP, Ayanian JZ, Balady G, et al. American College of Cardiology/American Heart Association Clinical Competence statement on stress testing: a report of the American College of Cardiology/American Heart Association/American College of Physicians—American Society of Internal Medicine Task Force on Clinical Competence. *J Am Coll Cardiol* 2000;36:1441–53.

Key Words: ACCF Training Statement ■ COCATS 3 ■ electrocardiogram ■ electrocardiography ■ ambulatory electrocardiography ■ exercise testing.

APPENDIX 1: ELECTROCARDIOGRAPHIC KNOWLEDGE BASE AND INTERPRETATION

Anatomy and Electrophysiology

1. Anatomy of the specialized conducting system (sinoatrial node, atrioventricular node, His bundle, bundle branches), concept of the trifascicular conduction system
2. Spread of excitation in the ventricles
3. Difference between unipolar and bipolar leads
4. Einthoven triangle; frontal and horizontal lead reference system
5. Vectorial concepts
6. Significance of a positive and negative deflection in relation to lead axis
7. Relation between electrical and mechanical activity

Technique and the Normal ECG

8. Effect of improper electrode placement (limb and precordial)
9. Effect of muscle tremor
10. Effect of poor frequency response of the equipment
11. Effect of uneven paper transport
12. Measurement of PR, QRS, QT, normal values/rate correction of QT interval
13. Normal ranges of axis in the frontal plane
14. Effect of age, weight, and body build on the axis in the frontal plane, as well as specific ECG diagnoses (i.e., left ventricular hypertrophy, left ventricular hypertrophy, and strain)
15. Normal QRS/T angle

16. Differential diagnosis of normal ST-T, T-wave variants (e.g., “juvenile” pattern and early repolarization syndrome)

Arrhythmias: General Concepts

17. Reentry, automaticity, triggered activity
18. Aberration (various mechanisms)
19. Capture and fusion complexes
20. Escape (passive, accelerated) complexes or rhythms: atrial, junctional, and ventricular
21. Interpolated premature beat
22. Parasystole (atrial, junctional, ventricular), modulated parasystole
23. Vulnerability
24. Exit block
25. Reciprocation
26. Concealed conduction
27. Supernormality

Arrhythmias: Recognition

Sinoatrial Rhythm

28. Sinus tachycardia
29. Sinus bradycardia
30. Sinus arrhythmia
31. Sinoatrial arrest
32. Sinoatrial block

Atrial Rhythms

33. Atrial premature complexes (conducted, nonconducted)
34. Atrial tachycardia (ectopic)
35. Atrial tachycardia with atrioventricular block
36. Atrial fibrillation
37. Atrial flutter (typical and atypical forms)
38. Multifocal atrial tachycardia
39. Wandering atrial pacemaker-multifocal atrial rhythm

Atrioventricular Node (Junctional)

40. Premature junctional complexes
41. Atrioventricular node re-entrant tachycardia (common and uncommon type)
42. Nonparoxysmal junctional tachycardia-accelerated junctional rhythm
43. Atrioventricular re-entrant or circus movement tachycardia with an accessory pathway
44. Escape complex or escape rhythm

Ventricular

45. Ventricular ectopic complexes
46. Accelerated idioventricular rhythm
47. Ventricular tachycardia: uniform (monomorphic), multiform (pleomorphic or polymorphic), sustained, nonsustained, bidirectional, and torsades de pointes
48. Ventricular flutter, ventricular fibrillation
49. Ventriculoatrial conduction

50. Ventricular escape or idioventricular rhythm

Atrioventricular Dissociation Due To:

51. Slowing of dominant pacemaker
52. Acceleration of subsidiary pacemaker
53. Above with depression of atrioventricular conduction
54. Third-degree atrioventricular block
55. Isorhythmic atrioventricular dissociation

Atrioventricular Block

56. First degree
57. Second degree; 2:1, Mobitz type I (Wenckebach), Mobitz type II, high-degree atrioventricular block
58. Third-degree atrioventricular block (complete)
59. Significance of wide versus normal QRS complex

Waveform Abnormality

Abnormalities of Repolarization (Concept of Primary and Secondary ST-T Wave Change); Abnormalities of U Wave; Ventricular Hypertrophy

60. Left ventricular hypertrophy: criteria for left ventricular hypertrophy; specificity and sensitivity of criteria
61. Right ventricular hypertrophy: criteria for right ventricular hypertrophy; sensitivity and specificity of the criteria
62. Biventricular hypertrophy
63. Electrical alternans

Atrial Abnormalities

64. Criteria for left atrial abnormality
65. Criteria for right atrial abnormality
66. Biatrial abnormality
67. Clinical significance of atrial abnormalities

Intraventricular Conduction Disturbances

68. Anatomic and electrophysiologic basis for intraventricular conduction defects
69. Criteria for incomplete and complete left bundle-branch block
70. Criteria for the diagnosis of incomplete and complete right bundle-branch block
71. Criteria for left anterior and posterior fascicular blocks
72. Concept of combined bundle and fascicular blocks
73. Indeterminate intraventricular conduction defects
74. Diagnosis and classification of pre-excitation syndromes (e.g., Wolff-Parkinson-White syndrome)

Myocardial Ischemia and Infarction

75. Transient ischemia and injury
76. Normal Q waves
77. Abnormal Q waves not associated with infarction
78. Differential diagnosis of tall R wave in right precordial leads
79. Theoretical basis of ECG changes in acute myocardial infarction (Q, ST-T waves)

80. Time course of ST-segment changes in acute myocardial infarction
81. Diagnosis of myocardial infarction (without Q waves)
82. ST-segment changes in conditions other than myocardial infarction
83. Localization of myocardial infarction
84. QRS residuals of old myocardial infarction
85. Reliability of QRS and ST-segment changes of myocardial infarction in previously abnormal ECG: intraventricular conduction defects; ventricular hypertrophy
86. Overall assessment of serial ECGs as to the probability of acute myocardial infarction

Pacemaker

87. Fixed-rate pacemaker
88. Atrial pacing
89. Ventricular demand pacing
90. Atrial triggered ventricular pacing
91. Atrioventricular dual pacing
92. Malfunctioning: demand acting as fixed rate; failure to sense; slowing of rate; acceleration of rate; failure to capture; failure to pace (inappropriate inhibition)

Exercise ECG Test

93. Criteria for a positive response
94. Significance of an abnormal baseline ECG; effect of drugs; effect of pre-excitation
95. Significance of heart rate and blood pressure response (normal and abnormal)
96. Sensitivity: false-negative (incidence and principal causes)
97. Specificity: false-positive (incidence and principal causes)
98. Significance of magnitude of ST-segment changes
99. Normal responses to maximum exercise testing
100. Exercise-induced rapid versus slow upsloping ST-segment depression
101. Exercise-induced minor versus abnormal horizontal or downsloping ST-segment depression
102. Exercise-induced ST-segment elevation in noninfarct-related versus infarct-related leads
103. Exercise-induced intraventricular conduction disturbance
104. Exercise-induced ventricular and supraventricular arrhythmias
105. Exercise-induced hypertensive or hypotensive response

106. Sensitivity, specificity, and predictive accuracy in clinical patient subsets
107. Identification of chronotropic incompetence or accelerated ventricular response
108. Utility of peak exercise capacity, ECG, hemodynamic response, and exercise-induced symptoms
109. Noncoronary causes of exercise-induced ST-segment depression
110. Exercise parameters that indicate adverse prognosis or multivessel coronary disease
111. Indications and contraindications for exercise testing
112. Exercise testing with ventilatory gas analysis
113. Exercise testing in special groups: women, asymptomatic subjects, post-revascularization patients, post-myocardial infarction or acute coronary syndrome patients
114. Evaluation of valvular heart disease
115. Evaluation of cardiac arrhythmias
116. Interpretation of exercise test results in subjects with resting ST-segment depression, left ventricular hypertrophy, Wolff-Parkinson-White syndrome, pacemakers, or cardiomyopathy

Clinical Diagnoses (Selected)

117. Hyperkalemia
118. Hypokalemia
119. Hypercalcemia
120. Hypocalcemia
121. Long-QT syndromes (congenital and acquired)
122. Atrial septal defect, secundum
123. Atrial septal defect, primum
124. Dextrocardia
125. Mitral stenosis
126. Chronic obstructive pulmonary disease
127. Acute cor pulmonale
128. Pericardial effusion
129. Acute pericarditis
130. Hypertrophic cardiomyopathy
131. Central nervous system disorder
132. Myxedema
133. Hypothermia
134. Sick sinus syndrome
135. Digitalis effect or toxicity
136. Effects of other drugs (e.g., tricyclic or antiarrhythmic agents)
137. Possible proarrhythmic effects

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Name	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
Dr. Bernard R. Chaitman	• CV Therapeutics • Merck	• Berlex • CV Therapeutics • Pfizer	• CV Therapeutics • GE Healthcare	• Pfizer	None	None	None
Dr. Gordon A. Ewy	None	None	None	• AstraZeneca • Kos Pharmaceuticals • Merck • Pfizer • Schering-Plough Pharmaceuticals • Wyeth Pharmaceuticals	None	None	None
Dr. Michael S. Lauer	None	None	None	None	None	None	None
Dr. Robert J. Myerburg	• Procter & Gamble • Reliant Pharmaceuticals	None	None	• Guidant • Procter & Gamble • Reliant Pharmaceuticals	None	None	• Guidant (Independent Panel on Device Malfunction)

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Name	Affiliation	Consultant	Research Grant	Scientific Advisory Board	Speakers' Bureau	Steering Committee	Stock Holder	Other
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Dr. Richard J. Kovacs	• Official—Board of Governors	• Biosignals • Eli Lilly • Oxford • Xenoplast	None	None	• CV Therapeutics	None	None	None
Dr. Rick A. Nishimura	• Official—Board of Trustees	None	None	None	None	None	None	None

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